A NEW SCHEME FOR ACOUSTICAL TOMOGRAPHY OF THE OCEAN

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Long-range propagation

LONG-TERM GOALS

The long-term purpose is to develop a new scheme of the acoustical tomography of the ocean of meso- to global scales which is based on measurements of horizontal-refraction angle (HRA) related to different acoustic modes rather than travel times along different rays.

SCIENTIFIC OBJECTIVES

To develop robust inversion scheme for retrieving 3-D ocean inner structure based on measurements of HRA. In spite of its small value HRA angle can be easily measured with the help of pair of mode-resolving line vertical arrays situated about 10 km apart (ocean interferometer). As a first approximation adiabaticity of mode propagation should be assumed. Then the scheme should be generalized to the case of non-adiabatic propagation with mode interaction taken into account in "N times 2-D" approximation, and appropriate computer simulations should be performed. Scattering of acoustic signals from internal waves should be also considered, and its effect on the accuracy of sound speed field retrieval should be estimated.

APPROACH

A low frequency tonal sound source (F = 30-100 Hz) is assumed to be towed by a vessel around the area of interest with typical horizontal scale of the order of 1000 km. Thus, the area is exposed from different directions, and HRA is known as a function of source position. Those data are then used for tomography inversion. It proceeds in two stages: 1) 2-D tomography which retrieves propagation constants of different modes at the nodes of horizontal rectangular grid covering the area. 2) 1-D tomography which retrieves sound speed profile (in terms of expansion with respect to a set of empirical orthogonal functions) at each node of horizontal grid based on already determined values of propagation constants.

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WORK COMPLETED

The inversion scheme described above was developed. Numerical simulations were conducted to check the scheme in the adiabatic case. Then mode interactions were taken into account, and appropriate iterative approach for inversions was developed. This approach was also realized as a software package, and appropriate numerical simulations were performed.

RESULTS

At the earlier stages of the research project it was found that in the adiabatic approximation the inversion scheme performs very well. The accuracy in measurements of source coordinates or ambient noise is not an issue for accomplishing this inversion scheme. The main source of errors in measurements of HRA lies in scattering from internal waves. The estimate shows that standard deviation of HRA error has the order of .001 rad. Averaging can reduce this value by a factor of 5. As a result the accuracy of retrieving the sound speed profiles for model eddy appeared to be less then 1 m/s for maximum value of deviation of sound speed and a few tens of cm/s for corresponding depth-averaged values. During 1997 the efforts were made to estimate the role of acoustic mode interaction. It was found, that the effects of mode interaction on HRA are usually small, and can be taken into account by appropriate rapidly converging iterative procedure with adiabatic propagation considered as a first approximation. Mention, that interaction effects themselves can be in fact not negligible, and corrections to modes'phase are significant. However, they cancel out for appropriate phase differences (HRA).

IMPACT/APPLICATIONS

The main conclusion is that the suggested acoustic tomography inversion scheme is feasible and can be practically used. Potential applications of the HRT for acoustic tomographic inversion of ocean frontal structure and solitons in coastal area are also promising. This scheme is simpler and cheaper than "traditional" time-of-flight based tomography, because: 1) it uses only simple low-power tonal signals; 2) there is no need in exact positioning of the source and exact time keeping; 3) interpretation of data and inversion technique is greatly simplified; 4) inversion is not subjected to "non-linear biases"; 5) duration of the tomography measurements is reduced significantly.

RELATED PROJECTS

An exact non-parabolic algorithm developed within the project "Non-parabolic marching algorithm for sound field calculations in the inhomogeneous ocean waveguide" was used for numerical simulations taking into account mode interactions.

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